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DECONTAMINATION and PROTECTION (U),

(8)

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[redacted]

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ABSTRACT

The objectives of Project 2.4 were to investigate the contamination characteristics of construction materials exposed at various angles and orientations to contamination resulting from high-yield-nuclear detonations and to investigate the effectiveness of various decontamination techniques, in order to obtain data on the radiological recovery of military installations.

Panels of various construction materials were mounted on board the YAG-39 and YAG-40, which were operated through regions of fallout after Shots Cherokee, Zuni, Flathead, Navajo, and Tewa. With the exception of Shot Tewa, the fallout contamination deposited on the YAGs from all these events was insignificant with respect to fulfilling the objectives of this project. The contaminated Shot Tewa panels were, unfortunately, exposed to heavy rainfall prior to receipt for study. Apparently, the rains effectively decontaminated the panels. The most heavily contaminated surface, an asphalt and gravel built-up roofing panel, read approximately 500 mr/hr when received from Shot Zuni at H+60 hours. Other panels were generally much less contaminated. Some gave readings barely above island background.

The limited data available indicated that small-particulate contamination, similar to Operation Jangle fallout, resulted from the land shots; and liquid contamination, similar to fallout from Shots Romeo and Union of Operation Castle, was produced from the deep-water barge shot. The particulate-type contaminant from Shot Zuni contaminated horizontal surfaces much more heavily than vertical surfaces. This is similar to observations at Operation Jangle. Conversely, the liquid contamination from Shot Flathead contaminated vertical surfaces much more heavily than horizontal surfaces, as was previously noted and reported during Operation Castle.

Contamination levels were generally reduced by factors of two-to-four by detergent scrubbing of the most heavily contaminated panels. Depth of penetration studies in painted wood revealed that the contamination was contained in the paint layers (120 to 300 microns thick). However, in all unpainted wood samples, the contaminant, after wetting, penetrated to depths of 1,000 to 2,000 microns, or more.

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DECONTAMINATION and PROTECTION

OBJECTIVES

The objectives of Project 2.4 were to study (1) the contamination characteristics of various types of building surfaces exposed at various angles and orientations to the fallout from high-yield-nuclear explosions and (2) the effectiveness of various decontamination procedures in order to obtain data on the radiological recovery of military installations constructed from these materials.

Background. The contaminating effects of Shot Baker of Operation Crossroads demonstrated that the wet contamination resulting from an underwater detonation of a nuclear weapon could present a serious and complex problem of decontamination of ships and nearby shore installations (Reference 1). However, with the exception of Operation Jangle, which produced a dry-particulate contamination, all field tests were conducted under essentially noncontaminating conditions until Operation Castle (Reference 2). No contamination-decontamination studies were conducted during Operation Ivy, in which the first thermonuclear device was detonated. Decontamination studies during Operation Castle bore out the previous laboratory and field studies that either the harbor-type or deep-water burst could produce a serious contamination problem (Reference 3).

The decontamination problem was first realized during Operation Crossroads. Subsequently, during Operation Greenhouse, a small-scale study was made on a limited variety of surfaces (Reference 4). However, the first time a large-scale effort was put forth to determine the extent of the contamination-decontamination problem for a harbor-type or a deep-water detonation was during Operation Castle. During the course of this operation, a systematic study was made of a wide variety of construction materials and a number of specific decontamination techniques. Several interesting and pertinent phenomena relating to the contamination-decontamination problem were revealed. The most notable was the fact that the vertical surfaces were more highly contaminated than the horizontal surfaces. This was unusual, considering the results of Operation Jangle in which the horizontal surfaces retained 5 to 300 times the activity retained on the vertical surfaces. Another unusual phenomenon of Operation Castle was the relatively high activity remaining after decontamination on painted and unpainted wood surfaces, and certain smooth roofing materials. The absence of any particulate matter after decontamination on these surfaces caused speculation as to the ionic nature of the contaminant remaining after decontamination. Only limited studies could be made after Operation Castle to determine the nature of the tenacious contaminant. A more detailed study to determine the true nature of the residual contamination after decontamination was planned for Operation Redwing.

Basic Theory. After Operation Castle, limited studies were made at the Army Chemical Center to determine the nature and depth of penetration of remaining contamination

on painted and unpainted wood surfaces of the decontaminated samples returned from Operation Castle. These studies included ion-exchange and complexing-agent decontamination, and depth of penetration tests. In the ion-exchange test, a carrier solution of strontium, cesium, iron, and lanthanum, applied to the surfaces for two hours, resulted in 60 percent decontamination. This decontamination effect of the carrier solution added strength to the theory that residual contamination remaining after decontamination is ionic in nature. Further decontamination studies using complexing agents produced up to 90 percent decontamination. The depth of penetration tests, by shaving the samples with a microtome 30 microns at a time, showed that the penetration of the contaminant into the painted and unpainted wood surfaces, after decontamination, was about 200 microns.

Taking into consideration the ionic nature of the remaining contamination after ordinary decontamination and the good additional decontamination effected by the complexing agents, it was felt that further experimentation was needed in the area of detergents and complexing agents. This project, therefore, proposed using the wetting agent, Igepal CO-630[1], in combination with the complexing agent Versene[2], in an effort to obtain 95 percent removal of residual ionic contamination. These agents were selected as the result of laboratory studies with discrete ionic contaminants.

DESIGN OF EXPERIMENT

Operational Concept. Project 2.4 was conducted in close coordination with the fallout projects which operated two specially equipped liberty ships. These ships traversed regions of predicted fallout, following high-yield detonations. Both ships, the YAG-39 and the YAG-40, were equipped with a salt-water washdown-countermeasure system, operated in selected portions of the ships.

Sets of panels of widely used construction materials (Table 1) were mounted at various pitches and orientations on a special frame (Figure 1). The complete assembly was mounted forward of the washdown region of the main deck of each ship. After the decontamination and following recovery of the ships, the panels were demounted at Site Elmer, where radiation surveys, decontamination operations, and radiochemical and radiophysical investigations of contaminants and decontamination wastes were made.

Project 2.4 participated in Shots Cherokee, Zuni, Flathead, Navajo, and Tewa. During each shot, panels on both YAGs were exposed. During Shot Navajo, panels were mounted on the YAG-39 only.

Description of Test Surfaces and Equipment. Test Panels. Four identical sets of test panels were fabricated. Each set consisted of fifty-two 2-by-4-foot panels of thirteen different construction material surfaces. Table 1 contains a description of the type of surface finish, mounting position, and location on the frame for each of the panels.

Panel-Mounting Frames. The panels were mounted on a structural-steel frame constructed like a cubical building with a half-gabled and half-flat roof. This was done to achieve a compact arrangement of the panels and, at the same time, to place them at slopes and orientations similar to those usually employed in constructed buildings. Each frame was equipped with eyebolts at each corner to facilitate easy and quick lifting by crane.

Panel Weather Covers. An attempt was made to provide canvas covers which could be affixed manually by shipboard personnel at H+12 hours. If successful, this would

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[1] Manufactured by General Aniline and Film Corporation, New York, New York
[2] Manufactured by Bersworth Chemical Company, Framingham, Massachusetts.

TABLE 1 CONSTRUCTION OF SPECIMEN PANELS

Panel Surface	Frame Location	Slope	Surface Finish
Asbestos cement shingles	Front side	Vertical	½ control * and ½ silicone Multiple pigment paint
	Port side	Vertical	½ control * and ½ silicone
	Starboard side	Vertical	½ control * and ½ silicone
Wood siding (clapboard)	Front side	Vertical	Control Lead and oil paint Multiple pigment paint Alkyd resin paint
	Port side	Vertical	Control Lead and oil paint Multiple pigment paint Alkyd resin paint
	Starboard side	Vertical	Control Lead and oil paint Multiple pigment paint Alkyd resin paint
Sheet metal	Front side	Vertical	½ control and ½ Epon resin Alkyd resin paint
	Port side	Vertical	Alkyd resin paint
	Starboard side	Vertical	Alkyd resin paint
Brick (medium density)	Front side	Vertical	Control Resin emulsion paint
	Port side	Vertical	Control
	Starboard side	Vertical	Control
Concrete block	Front side	Vertical	Control Resin emulsion paint
	Port side	Vertical	Resin emulsion paint
	Starboard side	Vertical	Resin emulsion paint
Poured concrete (smooth finish)	Front side	Vertical	Control Cement water paint
	Port side	Vertical	Control
	Starboard side	Vertical	Control
Stucco (coarse finish)	Front side	Vertical	Resin emulsion
	Port side	Vertical	Resin emulsion
	Starboard side	Vertical	Resin emulsion
Phenolic	Front side	Vertical	½ phenolic overlay board and ½ phenolic plywood
Concrete pavement	Top-front slope	Horizontal	Control
	Top-back slope	Horizontal	Silicone
Asphalt and gravel built-up roofing	Top-front slope	Horizontal	Control Polyvinyl alcohol
	Top-back slope	Horizontal	Control Polyvinyl alcohol
Roll roofing (smooth surface)	Top-front slope	3-in/ft	Control Polyvinyl alcohol
	Top-back slope	3-in/ft	Control Polyvinyl alcohol
Corrugated metal roofing	Top-front slope	3-in/ft	Control Asphalt protected
	Top-back slope	3-in/ft	Control Asphalt protected
Strip shingle roofing (mineral surface)	Top-front slope	6-in/ft	Control
	Top-back slope	6-in/ft	Control

* Control surfaces were untreated and represented basic material.

minimize weathering effects on the surfaces, which during Operation Castle may have caused partial decontamination before the start of recovery operations. However, this proved to be operationally unfeasible, due to wind flapping of the canvas, and unacceptable dosages to the crew.

Decontamination Stands. After recovery, the contaminated panels were mounted on simple wood stands at the Site Elmer decontamination area for decontamination operations. A drainage ditch was dug for the contaminated-runoff liquid.

Decontamination Materials. The materials for decontamination consisted of: (1) pump, centrifugal, gasoline-engine driven, delivery rate, 10 gal/min, 40 lb/in^2 nozzle pressure with a $\frac{1}{4}$-inch nozzle; (2) GI scrub brush with handle; (3) complexing agents, Versene, Igepal CO-630, and Tide detergent; and (4) hoses and nozzles.

Radiological Instrumentation. Two radiological-survey instruments were used: (1) Radiac survey instrument AN-PDR-39, an ionization-chamber survey meter; and (2) Tracerlab laboratory monitor, Model SU-3A, a Geiger-Muller counting-rate meter.

Radiochemical Equipment. Analyses of samples of the wash water to determine

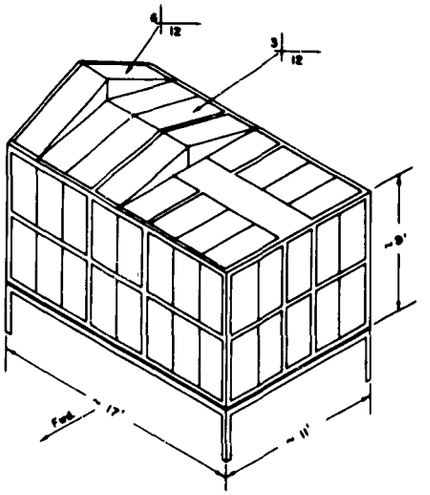

Figure 1 Frame and panel assembly

whether selective decontamination occurred was made by a single-channel gamma spectrometer, AEC Health and Safety Laboratories Type TM-10-A, loaned by Project 2.64.

The gamma spectrometer was a single-channel, automatic-sweep pulse-height analyzer. Its detector was a crystal of sodium iodide, thallium iodide activated, four inches in diameter and four inches high. The circuitry was designed to handle high-pulse rates, and the ratemeter section was calibrated in seven ranges from 100 to 100,000 counts/sec. The base line could be selected as 3, 1.5, or 0.75 Mev full scale, and swept automatically from one minute to four hours for the full energy scan. Data was displayed on an X-Y recorder, Mosely Autograf Model 2. The unit was powered from 115-volt, 60-cycle current.

Radiophysical Equipment. This phase of the task employed a Spencer microtome (Spencer Lens Company, Buffalo, New York) in studies to determine the depth of penetration of the contaminant into various surfaces. In this connection, radioautographs

were made using Kodak "M" metallographic plates. Darkroom facilities of Project 2.51 were used.

OPERATIONS

Contamination. Panels were secured to the frames on Site Elmer and placed on board the YAG-39 and the YAG-40 for Shots Cherokee, Zuni, Flathead, and Tewa, and on the YAG-39 only, for Navajo. The ships were maneuvered through fallout areas by shipboard personnel in a shielded control room below deck. Maximum contamination levels from fallout on the forward end of the ships are given in Table 2.

Recovery. After the maneuvers in the fallout areas, the ships returned to anchorage in the Eniwetok Lagoon off Site Elmer on D+2 day. Panels, if contaminated, were removed from the ships to the decontamination station for monitoring and decontamination.

Decontamination. Monitoring. Each panel was monitored separately for gamma radiation one inch above the surface, at eight equally-spaced points marked on the panel

TABLE 2 MAXIMUM CONTAMINATION LEVELS ON YAG–39 AND YAG–40 FORWARD AREA DURING FALLOUT

Event	YAG-39	YAG-40
Cherokee	Much less than 1 mr/hr	Much less than 1 mr/hr
Zuni	32 mr/hr at H + 25 hr	7.2 r/hr at H + 7 hr
Flathead	150 mr/hr at H + 11 hr	250 mr/hr at H + 17 hr
Navajo	1.3 r/hr at H + 5 hr	110 mr/hr at H + 13 hr
Tewa	25 r/hr at H + 4.5 hr	5.2 r/hr at H + 7 hr

on an approximate one-foot grid. In this manner, one reading was taken at the center of each square-foot area. This was done before decontamination operations were begun, after each such operation, and at the beginning and end of each day. A monitoring jig was attached to the AN-PDR-39 to assure accuracy of position for all readings. Background readings were taken periodically for purposes of data correction.

Decontamination Methods. Each panel was subjected to a variety of decontamination techniques applied in the order given below. This order was based on initial employment of the mildest method known, as determined by previous laboratory investigation, followed by the more-severe treatments. Economic considerations and limited availability of space on the test ships precluded the furnishing of a separate panel for each decontamination operation.

The decontamination methods employed were: (1) low-pressure hosing, for a period of 30 seconds per panel ($\frac{1}{4}$-inch nozzle with a nozzle pressure of 8 lb/in^2); (2) fire-pressure hosing for a period of 15 seconds per panel ($\frac{1}{4}$-inch nozzle with a nozzle pressure of 40 lb/in^2); (3) scrubbing with brush and water, followed by a low-pressure water rinse; (4) detergent scrub (one percent of Tide by weight) followed by a low-pressure water rinse;

and (5) detergent scrub (0.5 percent of Versene by weight, one percent Igepal CO-630 by volume) followed by a low-pressure water rinse. For all scrubbing operations, the actual scrubbing time was 30 seconds per panel; the subsequent water rinse was applied for approximately five seconds.

Hosing was done with the nozzle pointed directly at vertical panels from a distance of eight feet. Roof panels were hosed from a distance of three feet, with the stream impinging at a 30-degree angle to the surface.

Radiochemical Studies. In order to determine whether or not selective decontamination occurred and which nuclides were most affected by the different decontamination methods, samples were taken of the runoff water from each decontamination operation for the Shot Flathead panels. Also, small pieces of the panel specimens were retained for further study. The samples were given a rough analysis by a single-channel gamma spectrometer loaned by Project 2.64. Selected panel surfaces were returned to the Army Chemical Center for a more-detailed investigation into the specific nuclides removed, and their extent of removal. However, the lightly contaminated samples decayed to such low levels upon receipt that no useful data could be obtained.

Radiophysical Studies. To determine the manner of distribution of the contamination in the various wooden surfaces, small board strips were removed from each type of wood surface. These were cut into one-inch squares. Three samples of each of the four types of wood surfaces were placed on a photographic plate and radioautographs obtained for each type surface. Figure 2 shows prints of the radioautographs from the various shots.

The wood samples were then placed in the sample holder of the Spencer microtome, and the blade was aligned and set to shave 30 microns from the sample, per swipe. In order to obtain a clean slice, however, two passes had to be made over the sample, for one slice. Therefore, 60 microns were removed per slice. (This was checked with a Brown and Sharp Model 20 micrometer using cold samples.) The radioactivity of the samples was then measured using a Model SU3 Tracerlab-lab monitor for samples analyzed on Eniwetok, and with a Berkely Model 2000 scaler for samples analyzed at Army Chemical Center. Each of the above instruments employed a Tracerlab end-window-GM tube with a 1.7 mg/cm^2 mica window.

RESULTS

Calculations. Radiation intensity readings for each surface were averaged and corrected for background. These were then corrected for decay to H+60 hours. Decay corrections were made assuming the -1.2 decay exponent.

The average residual percentage for each surface is the ratio, $\times 100$, of the average residual gamma-dose rate after a particular decontamination process, to the average initial gamma-dose rate for a given panel.

Summary. In general, the radiation from the fallout retained on the panels was too low to yield good experimental data. Table 2 gives the average of the maximum gamma-dose readings recorded on the most forward recorder stations on the two YAGs. This information was furnished by Project 2.71.

During Shot Flathead, only the front panels on the YAG-40 were contaminated sufficiently to warrant investigation. The gamma-dose rates on the YAG-39 from Shot Navajo would lead one to expect that the panels from this ship should be contaminated at least as much as

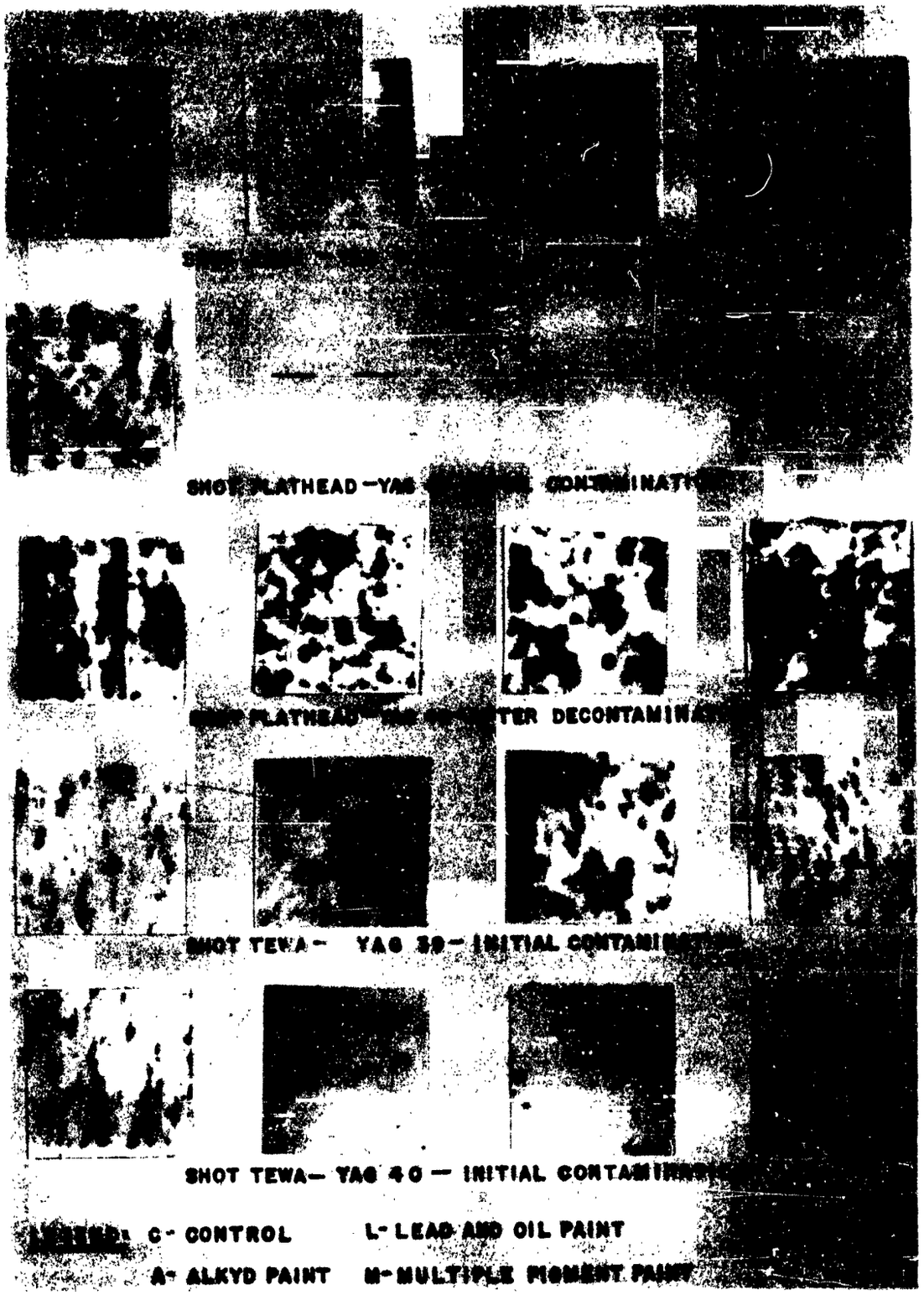

Figure 2 Radioautographs of wood samples.

those from the YAG-40 at Shot Flathead. However, examination of Project 2.71 recorder-station data shows a drop in gamma background by a factor of two, on the ship at about H+16 hours. This was probably caused by a rainstorm and would account for the lower contamination levels on the panels.

Panel contamination from Shot Tewa, upon recovery, was too low compared to the high background level on Site Elmer to yield satisfactory data. The low-contamination level of these panels is attributable to the torrential rains which occurred between shot time and recovery. Site Elmer received fallout from Shot Tewa and had a gamma background from 40 to 60 mr/hr at the time the panels were received. The highest reading that could be detected on the panels, as measured on Site Elmer, was 80 mr/hr, which included the background reading.

The decontamination methods numbered on Tables 3 and 4 refer to the operations discussed on Page 13: Method 1, low-pressure hosing; Method 2, fire-pressure hosing; Method 3, water scrub; Method 4, scrub with Tide; and Method 5, scrub with Versene plus Igepal CO-630.

Table 3 summarizes the average gamma-dose rates for the YAG-40 Shot Flathead front-face panels before decontamination, and the residual percentages based on these levels.

Table 4 summarizes the average gamma-dose rates for the YAG-40 Shot Zuni panels before decontamination, and the residual percentages based on these levels.

DISCUSSION

Contamination-Decontamination Phenomena. The panel contamination resulting from each shot was disappointingly low. Shot Cherokee, the air burst, produced no detectable contamination. Shot Zuni, a land-surface burst, contaminated the YAG-40 panels lightly and unevenly. At sixty hours after the burst, the maximum-contamination level was 500 mr/hr on an asphalt and gravel built-up roofing panel. Other panels generally were much less contaminated, with some readings barely above background. Accordingly, little information can be derived from these data. Shot Flathead, a deep-water-barge shot, lightly contaminated the front-face panels on the YAG-40, while Shot Navajo, also a barge shot, produced negligible contamination. Shot Tewa, a very-shallow-water-barge shot, apparently contaminated the ships and panels, as evidenced by recorder readings on the decks. Subsequently, torrential rains fell on the panels, and only negligible contamination could be detected upon their recovery.

The few observations that may be made are based generally on the Shot Zuni data. The Shot Zuni contaminant visually appeared to be a very fine powder. The flat asphalt and gravel built-up roofs, the roughest of all surfaces, became the most highly contaminated from this event, with the levels being at least two to three times higher than any other panel readings. The Shot Zuni horizontal and pitched-roof panels were, with a few exceptions, more highly contaminated than the vertical panels. This was similar to observations made during Operation Jangle. Hosing was relatively ineffective on most panels, but scrubbing with detergents generally resulted in effective decontamination. It was noted that the ship's gamma-recorder data for this event showed little or no evidence of weather-produced decontamination, prior to panel recovery by this project. The fallout from Shot Flathead contaminated vertical surfaces much more heavily than horizontal surfaces, in a manner similar to observations made at Shots Romeo and Union during Operation Castle.

Some of the data in Tables 3 and 4 show an increase in residual percentages after certain decontamination operations. This is attributed generally to the low panel-contamination levels, which were approaching the 5 to 7 mr/hr decontamination-area-background levels at the time.

Data Limitations. In view of the extremely low contamination levels and meager data de-

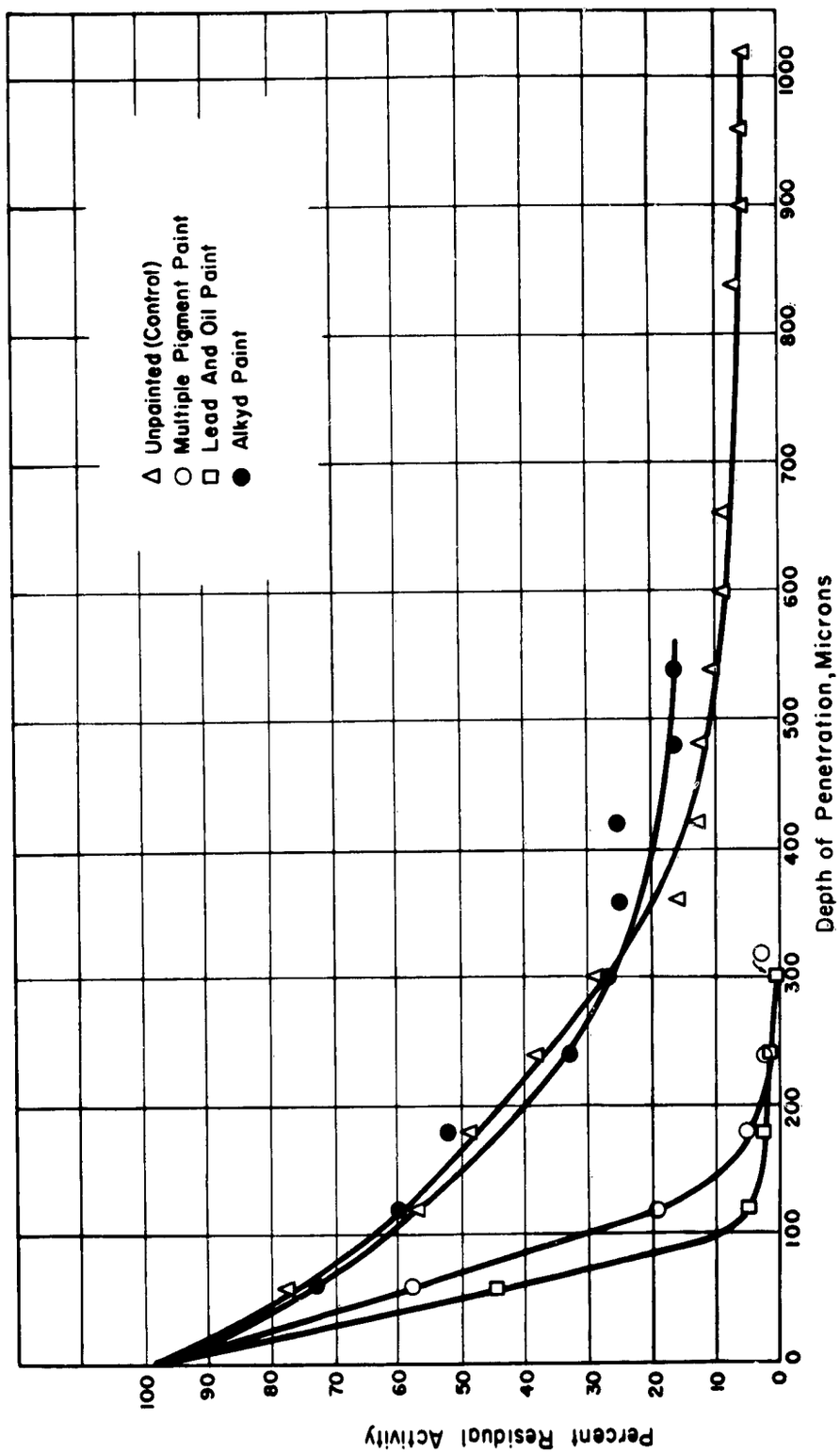

Figure 3 Shot Zuni, YAG-40, contaminant penetration into wood surfaces after decontamination.

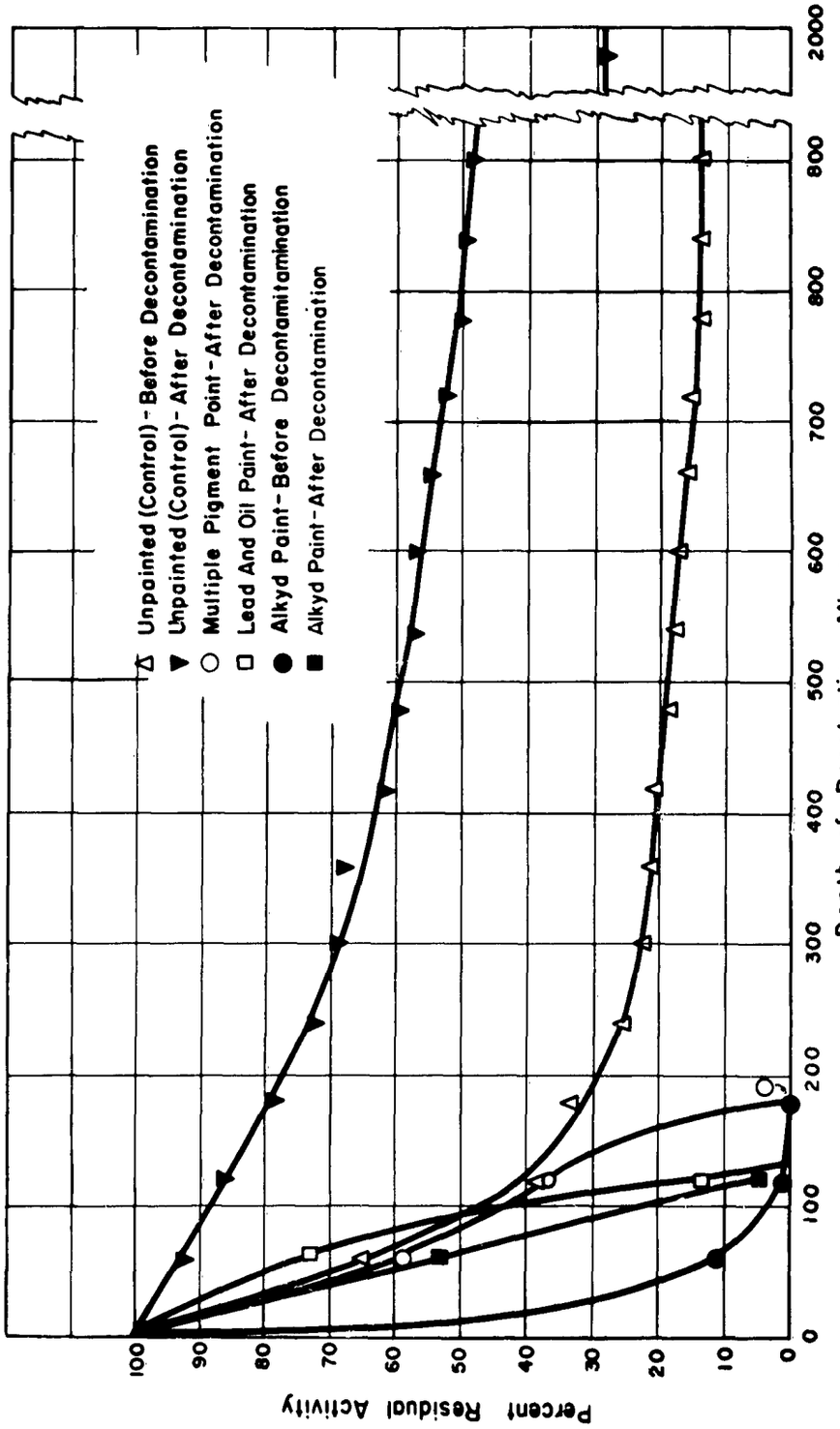

Figure 4 Shot Flathead, YAG-40, contaminant penetration into wood surfaces.

rived therefrom, extrapolation of any apparent contamination-decontamination phenomena to higher contamination levels is inadvisable.

This project had planned to participate in three events. In an effort to obtain useful data and fulfill its objectives, Project 2.4 extended its participation to five events. Nevertheless, the project failed to obtain panels which had retained fallout contamination levels of interest. Of course, this in itself is of some significance. It would have been ideal, with respect to the objectives of this project, for the panels to have been exposed to fallout levels of 1,000

TABLE 3 SHOT FLATHEAD, YAG-40 INITIAL CONTAMINATION (AT H + 60 HOURS) AND RESIDUAL PERCENTAGES AFTER DECONTAMINATION

Location symbol: F - forward face of frame.

Surface Material	Finish and Location	Initial Contamination Level	Residual Percentages, Corrected for Decay Method Used			
			Before Decon.	3	4	5
		mr/hr				
Asbestos cement shingles	Control (F)	41	100	71	61	45
	Multiple pigment paint (F)	32	100	42	17	8
Wood siding (clapboard)	Control (F)	75	100	70	54	39
	Lead and oil paint (F)	47	100	61	28	30
	Multiple pigment paint (F)	24	100	44	11	*
	Alkyd resin paint (F)	42	100	22	10	3
Sheet metal	Alkyd resin (F)	12	100	33	11	*
	Epon resin (F)	15	100	18	*	*
Brick (medium density)	Control (F)	107	100	84	80	79
	Resin emulsion paint (F)	45	100	47	38	29
Concrete block	Control (F)	61	100	72	70	63
	Resin emulsion paint (F)	36	100	52	37	33
Poured concrete (smooth finish)	Control (F)	129	100	56	63	48
	Cement water paint (F)	103	100	53	40	28
Stucco (coarse finish)	Resin emulsion paint (F)	57	100	51	37	30
Special phenolic	Phenolic overlay board and plywood (F)	36	100	74	70	59

* Background readings.

r/hr or more at H+1 hour. However, the highest fallout field encountered by the ships was 25 r/hr at H+4.5 hour, or about 150 r/hr extrapolated to H+1 hour.

Physical and Chemical Investigations of Surfaces. Radiophysical Studies. Figure 2 shows the radioautographs of the wood samples taken from panels after various shots. Note that the samples of Shot Zuni show a fine speckled effect, as if fine particulate matter had impinged on the surface. This may well have been what actually happened, since a fine white particulate contamination was found all over the YAG-40 after this shot. Note also that the painted wood samples for Shot Zuni all have a general uniform darkening on the right edge of the sample. This darkening corresponded to a blackening on the original sample, caused by the beating of the black canvas covers on the panel frame. The

black resinous impregnation in the canvas soiled the clapboard edges of all the painted wood panels, and evidently held the contamination to the panel surface. Decontamination procedures did not remove this contamination.

The contamination on the Shot Flathead samples shows up somewhat differently. Unfortunately, radioautographs of the painted-wood samples before decontamination were not taken. However, the control samples show the same general contamination distribution found on the painted-wood samples. It can be seen that the contamination still has a speckled effect, but of much larger spots, or more of a polka-dot effect. This is believed to be due to a liquid-raindrop type of contamination in Shot Flathead, rather than the fine particulates of Shot Zuni. The radioautographs of the decontaminated Shot Flathead samples show a splotchy effect, with slight darkening in the background. This seems to indicate that the decontamination methods actually caused the residual contamination to permeate the wood, producing the splotchy effect seen.

No panels were advertently decontaminated after Shot Tewa, therefore the radioauto-

TABLE 4 SHOT ZUNI, YAG–40 INITIAL CONTAMINATION (AT H + 60 HOURS) AND RESIDUAL PERCENTAGES AFTER DECONTAMINATION

Location symbols: F - forward face of frame; P - port face of frame; S - starboard face of frame; FS - front slope of frame; BS - back slope of frame.

Surface Material	Finish and Location	Initial Contamination Level	Residual Percentages, Corrected for Decay Method Used					
			Before Decon.	1	2	3	4	5
		mr/hr						
Asbestos cement shingles	Control (F)	80	100	57	38	44	41	41
	Multiple pigment paint (F)	33	100	82	42	51	45	45
	Control (P)	15	100	80	100	50	*	*
	Control (S)	28	100	58	50	41	*	*
Wood siding	Control (F)	35	100	58	54	31	31	31
	Lead and oil paint (F)	19	100	84	74	35	*	*
	Multiple pigment paint (F)	21	100	66	38	26	*	*
	Alkyd resin paint (F)	19	100	79	74	37	*	*
	Control (P)	12	100	71	33	37	*	*
	Lead and oil paint (P)	24	100	65	50	23	*	*
	Multiple pigment paint (P)	17	100	74	59	50	*	*
	Alkyd resin paint (P)	21	100	76	57	38	*	*
	Control (S)	55	100	47	38	29	20	27
	Lead and oil paint (S)	23	100	78	61	37	*	*
	Multiple pigment paint (S)	25	100	66	56	22	*	*
	Alkyd resin paint (S)	14	100	68	57	*	*	*
Sheet metal	Alkyd resin paint (F)	10	100	90	50	50	*	*
	Epon resin paint (F)	12	100	58	58	41	*	*
	Alkyd resin paint (P)	13	100	73	61	58	*	*
	Alkyd resin paint (S)	11	100	64	55	*	*	*
Brick (medium density)	Control (F)	33	100	82	82	69	55	55
	Resin emulsion paint (F)	26	100	85	85	65	50	58
	Control (P)	7	*	*	*	*	*	*
	Control (S)	76	100	98	67	62	54	61
Concrete block	Control (F)	50	100	84	72	63	56	60
	Resin emulsion paint (F)	28	100	86	68	59	46	61
	Resin emulsion paint (P)	4	*	*	*	*	*	*
	Resin emulsion paint (S)	20	100	80	70	38	*	*

* Background readings.

TABLE 4 (CONTINUED)

Location symbols: F - forward face of frame; P - port face of frame; S - starboard face of frame; FS - front slope of frame; BS - back slope of frame.

Surface Material	Finish and Location	Initial Contamination Level	Residual Percentages, Corrected for Decay Method Used					
			Before Decon	1	2	3	4	5
		mr/hr						
Poured concrete (smooth finish)	Control (F)	32	100	81	69	53	41	47
	Cement water paint (F)	19	100	84	84	65	47	58
	Control (P)	2	*	*	*	*	*	*
	Control (S)	22	100	86	68	59	*	*
Stucco (coarse finish)	Resin emulsion paint (F)	29	100	83	66	60	57	57
	Resin emulsion paint (P)	5	*	*	*	*	*	*
	Resin emulsion paint (S)	23	100	85	61	54	*	*
Special phenolic	Phenolic overlay board and plywood (F)	30	100	75	53	52	50	50
Concrete pavement	Control (FS)	63	100	41	30	21	*	*
	Silicone resin (BS)	43	100	57	49	25	*	*
Asphalt and gravel built-up roofing	Control (FS)	223	100	52	37	26	17	15
	Polyvinyl alcohol (FS)	496	100	67	51	45	37	35
	Control (BS)	179	100	61	45	29	20	17
	Polyvinyl alcohol (BS)	316	100	66	52	42	36	34
Roll roofing (smooth surface)	Control (FS)	42	100	63	60	21	*	*
	Polyvinyl alcohol (FS)	51	100	49	45	18	*	*
	Control (BS)	72	100	44	38	17	*	*
	Polyvinyl alcohol (BS)	49	100	45	33	19	*	*
Corrugated metal roofing	Control (FS)	38	100	61	58	7	*	*
	Asphalt protected (FS)	71	100	51	42	8	*	*
	Control (BS)	34	100	64	62	24	*	*
	Asphalt protected (BS)	42	100	55	45	14	*	*
Strip shingle roofing (mineral surface)	Control (FS)	165	100	71	44	45	35	25
	Control (BS)	178	100	71	49	43	32	24

* Background readings.

graphs all represent the distribution of the initial contamination. It should be recalled, however, that these panels had been subjected to heavy rainfall. One sees in these radioautographs a particulate effect intermediate between the fine speckled effect of Shot Zuni and the polka-dot effect of Shot Flathead. Actually, after Shot Tewa, so little contamination stuck to the panel rack that about the highest reading taken on any panel was about twice the high island background. The samples from the YAG-39 were lightly contaminated, while those from the YAG-40, except the control samples, were so cold that even after a week's exposure, the shading on the photographic plate was still very slight. The spotty effect was apparent, however, although very faint.

Figures 3, 4, and 5 are graphs of the contamination-penetration studies which were carried out when and where, time and radiological situation permitted. It has previously been noted that for every event this project participated in, the contamination levels on the panels, upon receipt, were disappointingly low. It was noted that this was due to

either one or both of the following reasons: (1) only a low level of fallout contamination ever impinged on the panels; (2) removal of fallout contamination from the panels by inadvertent exposure to heavy rains subsequent to contamination and prior to receipt of the panels at Site Elmer, for study.

Consider, for example, Figure 5 which purports to present depth of penetration of contaminant before decontamination. This is true where decontamination is defined as advertent or deliberate removal of contaminant. Actually, however, these panels were all washed (decontaminated) by heavy rains prior to receipt at Site Elmer. The contamination levels were, consequently, so low that further penetration studies after their deliberate decontamination would have been meaningless. Furthermore, it is obvious that no before-and-after-decontamination comparisons of the Shot Tewa contaminant penetration can be made.

Figure 3 concerns Shot Zuni studies. This was the first contaminating event in which this project participated. The panels, upon receipt at Site Elmer, were contaminated to such low levels that no attempt was made to determine depth of contaminant penetration prior to decontamination. It was only after the decontamination procedures failed to effect complete decontamination, that the depth of penetration studies on the decontaminated panels was conducted to ascertain where the residual contaminant lay.

Figure 4 illustrates Shot Flathead studies. Here, although the contamination level on the panels was again very low, depth of contaminant-penetration studies (both before and after decontamination) were made on some of the panels.

In view of the foregoing, only qualitative generalizations can be made about contaminant penetration. The most striking observation is that wetting of the contaminated unpainted-wood panels resulted in penetration of the contaminant deeper into the wood to depths of 1,000 to 2,000 microns or more. This is most evident by comparison of the two uppermost curves in Figure 4. Further, a comparison of the unpainted wood samples, after decontamination, in Figures 3 and 4, indicated that the probably-more-soluble-liquid contaminant of Shot Flathead is washed more thoroughly into the wood panel than is the probably-less-soluble particulate contaminant of Shot Zuni.

The results obtained from all the painted surfaces were somewhat erratic, but in general showed that contaminant penetration, even after decontamination, was seldom greater than the depth of the paint. (Paint thickness varied between 180 and 300 microns.) The alkyd paint surfaces seemed to permit a greater contaminant penetration than the other paints. It should be noted here that, in general, the painted vertical surfaces became less contaminated, by a factor of about two, initially, than their unpainted counterparts. All in all, the trend of the results seemed to corroborate previous investigations in showing that painting absorbing surfaces considerably increased their resistance to contamination, and made them more susceptible to decontamination than unpainted absorbing surfaces.

Spectrometer Analysis. Attempts were made to determine gamma spectra of wash water from Shot Flathead wood and masonry wall panels by a single-channel gamma spectrometer. Analysis of the results was impractical due to apparent drifting of spectrometer settings to the extent that calibration data could not be applied. Samples returned to the Army Chemical Center were too cold upon receipt to warrant further study.

CONCLUSIONS

1. The objectives of this project were inadequately fulfilled. This was due entirely to the low levels of contamination which were found on the panels upon receipt for study. This, in turn, was due to either one or both of the following reasons: (1) low levels of fallout contamination encountered by the YAGs, on which the panels were located, and

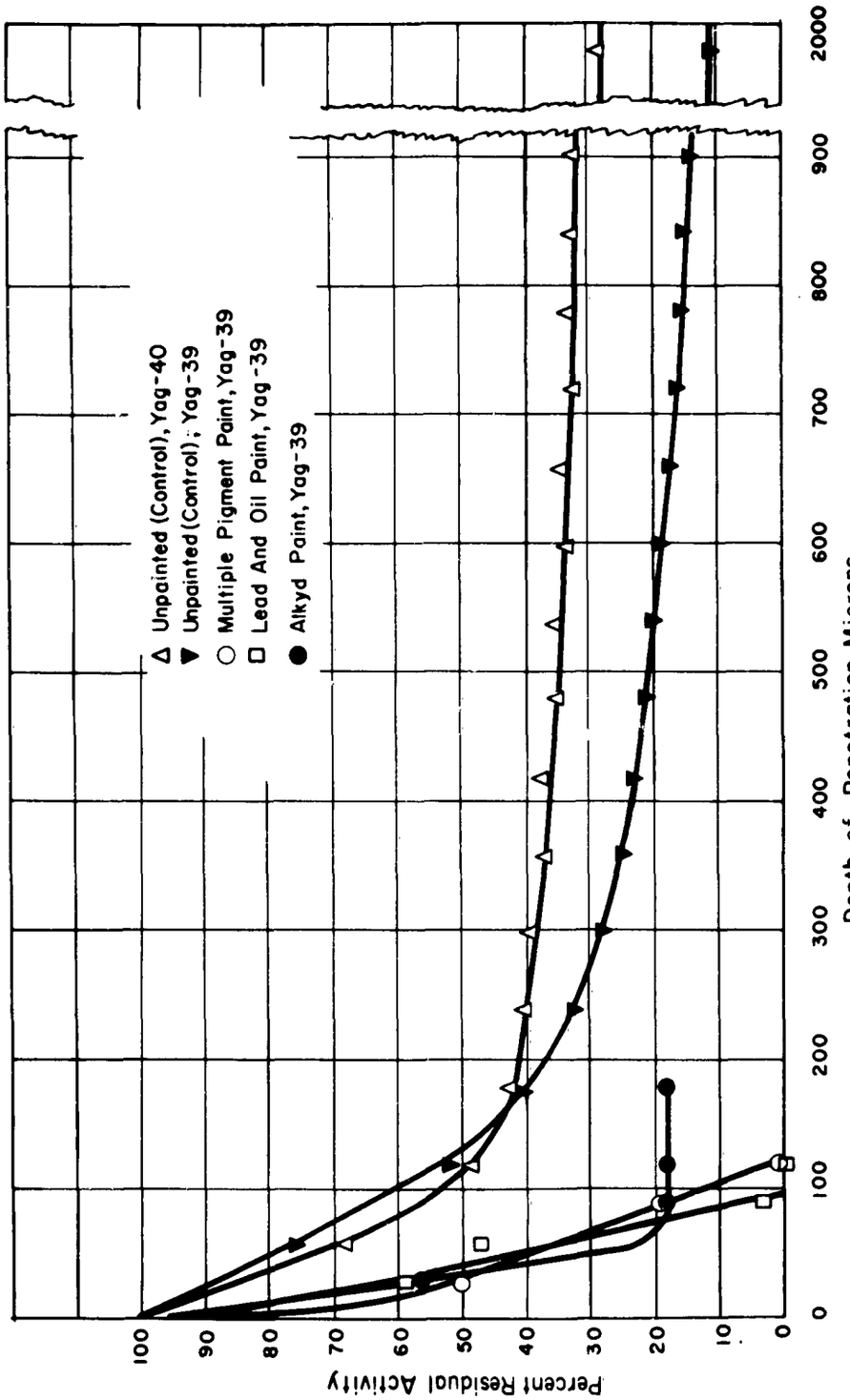

Figure 5 Shot Tewa, YAG-39 and YAG-40, contaminant penetration into wood surfaces before decontamination.

or (2) exposure of the panels, while on the YAGs, to heavy rainfall subsequent to contamination and prior to receipt for study. Accordingly, only qualitative studies could be conducted and general observations made.

2. The land surface shots produced small-particulate contamination (similar to Operation Jangle fallout), while the deep-water barge shots produced liquid contamination (similar to fallout from Shots Romeo and Union of Operation Castle).

3. Horizontal surfaces became more heavily contaminated than vertical surfaces from particulate contaminant, similar to observations at Operation Jangle. However, vertical surfaces became more heavily contaminated than horizontal surfaces from liquid contaminant, as was previously reported during Operation Castle.

4. The most effective decontamination method, for the most heavily contaminated panels, appeared to be detergent scrubbing.

5. The contaminant was generally contained in the paint layers (120 to 300 microns thick) on painted wood panels, but upon wetting would penetrate to depths of 1,000 to 2,000 microns, or more, on unpainted wood panels.

RECOMMENDATIONS

It is recommended that contamination-decontamination studies of construction surfaces at nuclear test operations at the Eniwetok Proving Ground (EPG) be curtailed. However, such studies should be considered for other surface or sub-surface detonations where the physico-chemical nature of the contaminant can be expected to be radically different than that which exists at either the EPG or Nevada Test Site.

REFERENCES

1. W. F. Strope and others; Chapter I, "Historical Experience" of "Radiological Defense", Volume II; AD-213 (Y), April 1950; U. S. Naval Radiological Defense Laboratory, San Francisco, California; Unclassified.

2. J. R. Earl and others; "Protection and Decontamination of Land Targets and Vehicles"; Project 6.2, Operation Jangle, WT–400, June 1952; U. S. Naval Radiological Defense Laboratory, San Francisco, California; Chemical and Radiological Laboratories, Army Chemical Center, Maryland; Engineer Research and Development Laboratories, Fort Belvoir, Virginia; and Office of the Chief of Engineers, Washington, D. C.; Secret, Restricted Data.

3. J. C. Maloney, E. H. Dhein and M. Morgenthau; "Decontamination and Protection"; Project 6.5, Operation Castle, WT–928, May 1954; Chemical and Radiological Laboratories, Army Chemical Center, Maryland; Confidential, Formerly Restricted Data.

4. L. B. Werner and S. R. Sinnreich; "Contamination-Decontamination Studies"; Annex 6.7, Operation Greenhouse, WT–27, August 1951; U. S. Naval Radiological Defense Laboratory, San Francisco, California; and Army Chemical Center, Maryland; Confidential, Formerly Restricted Data.

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